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Institut für Physik
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INSTITUTSKOLLOQUIUM

Gemeinsames Kolloquium der Physik und Chemie

Am Dienstag, dem **28. Mai 2024**, spricht um **17:15 Uhr** im **Faraday-Hörsaal,**

Prof. Dr. Daniel Vanmaekelbergh

Debye Institute for Nanomaterials Science, Utrecht University

zum Thema:

„Colloidal Bi_2Se_3 platelets with helical quantum channels and high-energy surface excitations“

Abstract:

Colloidal nanocrystals underwent a tremendous development with full control over dimensions and surface chemistry, resulting in vast opto-electronic applications. *Can they also form a platform for quantum materials, in which electronic coherence is key?* Here, we use colloidal, two-dimensional Bi_2Se_3 crystals, uniform in thickness and with limited lateral dimensions, as a model system to study the evolution of a three-dimensional topological insulator to the technologically important case of two-dimensions and limited crystal domains.

We have studied individual Bi_2Se_3 platelets with diameter in the 100-200 nm range and well-defined thickness (1-6 quintuple layers) with cryogenic scanning tunneling microscopy and spectroscopy. For 4-6 Bi_2Se_3 quintuple layers, we observe an edge state, 8 nm wide, around the entire crystal. The edge state is faint or absent for thinner (1-2 QLs) Bi_2Se_3 platelets. The edge states are resilient under a perpendicular magnetic field. Ab-initio calculations confirm that crystals with 3 QLs or more have a non-trivial band structure with a one-dimensional quantum channel at the edge. The quantum channel consists of 2 counter propagating states with momentum-spin locking. Such states are key for non-dissipative information transfer and quantum computing.

In addition, we have performed optical spectroscopy in the high energy region (1-3 eV). We were able to classify the optical transitions as (1) transitions due to the surface (outer QLs) or (2) due to the inner QLs. By comparison with GW simulations, we identified all transitions in a (energy, momentum in x, momentum in y) two-dimensional Brillouin zone frame. Some transitions show electron and hole cooling in which the carriers separate in momentum space.

Colloidal Bi2Se3 platelets are not only a model system for a two-dimensional toplogical insulator, but also a layer semi-metal with exotic optical transitions. The processability and dimensional control of topological insulator colloidal nanocrystals opens a unique window to devices with a large density of addressable quantum states.

Wir laden Sie zu diesem Kolloquium herzlich ein!

Die Hochschullehrer der Institute für Physik und Chemie